PATENT SPECIFICATION (11) 1 372 858

(21) Application No. 59311/71 (22) Filed 21 Dec. 1971 (19)

(31) Convention Application No. 120690/70 (32) Filed 29 Dec. 1970 in

(33) Japan (JA)

(44) Complete Specification published 6 Nov. 1974

(51) International Classification B60C 11/00 B29H 17/14 17/26 B60C 13/00 9/04 9/20

(52) Index at acceptance B7C 3B7 3B9 3D5

1 372 858

(54) RADIAL TIRE AND METHOD OF MANUFACTURING THE SAME

(71) We, BRIDGESTONE TIRE KABUSHIKI KAISHA, of No. 1—1, 1-Chome, Kyobashi, Chuo-Ku, Tokyo, Japan, a company organized according to the laws of Japan,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to radial tires, and more particularly to a method of manufacturing radial tires having a carcass including one or more rubberized cord plies whose cords are disposed substantially along radial planes containing the axis of rotation of the tire. The invention also relates to pneumatic radial tires manufactured by the process described.

A radial tire generally comprises a carcass including one or more carcass plies whose cords are disposed substantially on tire meridian planes or radial planes containing the axis of rotation of the tire, a breaker mounted on the outer peripheral surface of the carcass along the equator of the tire, the breaker having cords disposed at an angle of between 5° to 25° relative to the equatorial plane of the tire, and a tread secured to the carcass so as to cover the breaker. The tire breaker acts to reinforce the tire crown.

Thus the angle of disposition relative to the equatorial plane of the carcass cords of the radial tire is greatly different from that of its breaker cords. More particularly, the angular difference between the carcass cords and the breaker cords is 60° to 80° for radial tires, whereas the corresponding angular difference for conventional cross-ply tires is about 10°. As a result, the conventional one-step formation of the green casings of cross-ply tires, in which all the tire making operations, inclusive of assembling and shaping of various components into a green casing are carried out on a cylindrical tire former, cannot be used for manufacturing radial tires.

Accordingly, radial tire green casings have conventionally been made by a two-step process; namely, a first step of stretching and forming a carcass on a cylindrical former, together with bead wires, chafers, and rubber stiffeners to be incorporated in the carcass, followed by application of side wall rubber layers; and a second step of flexing the carcass formed in the first step into a toroidal shape having a cross-section similar to that of a finished radial tire. In the second step, a breaker having a width substantially equivalent to the width of a tire tread and a tread rubber layer are successively secured to the outer crown portion of the carcass thus shaped. Such a complex process is necessitated by the large angular difference referred to above between the carcass cords and the breaker cords, in the case of the radial tire.

The tread rubber layer and the side wall rubber layers co-operate to form a continuous rubber layer covering almost the entire outer surface of the tire including the crown portion, which comes in contact with the road surface, opposite shoulder portions, and opposite side wall portions extending to the close proximity of the tire bead regions. The crown portion of the continuous rubber layer is required to have certain performance characteristics which are different from those required for the side wall portions thereof. More particularly, abrasion resistance is required for the crown portion, because the crown portion contacts the road surface. On the other hand, flexibility is required for the side wall portions, because the side wall portions must flex upon loading. It should be noted that the extent of the flexing of the radial tire side wall portions upon loading is considerably larger than that of conventional cross-ply tires.

The abrasion resistance and the flexibility are incompatible properties of rubber materials, so that different kinds of rubber materials are used for the crown portion and for the side wall portions of radial tires. Usually, a rubber material having a Shore A hardness of from 55° to 75° is used for the

[Price 25p]

crown portion, while a rubber material having a Shore A hardness of from 40° to 55° is used for the side wall portions. As indicated above, the side wall portions are secured to the carcass in the first step, while the tread rubber layer is mounted in the second step. If a composite rubber layer having both the tread portion and the side wall portions in one piece is applied in the second step, radially inner edge portions of the side wall rubber layers, which are comparatively closer to the axis of rotation of the tire, tend to wrinkle due to the difference of radii between the radially inner portion and the radially outer portion of the tire. Such wrinkles make the tire shaping difficult.

The invention in one aspect provides a method of manufacturing a pneumatic radial tire, comprising: forming a carcass including at least one rubberized carcass ply on a cylindrical former, securing a pair of flexible side wall rubber layers to said carcass, said carcass ply consisting of cords disposed to lie at from 70° to 90° to the equatorial plane of the finished tire, said side wall rubber layers having a Shore A hardness of from 40° to 55° (when vulcanized); forming a green casing by flexing the carcass thus formed into a toroidal shape, securing a rubberized breaker layer and a preformed tread rubber layer to the crown portion of the carcass by stitching, said breaker layer consisting of cords disposed to lie at from 10° to 30° to the equatorial plane of the finished tire, said tread rubber layer comprising a central body portion made of an abrasion-resistant hard rubber material with a Shore A hardness of from 55° to 75° (when vulcanized) and a pair of edge portions made up of the same rubber material as said side wall rubber layers and integrally pre-bonded to said central body portion, said stitching bonding said abrasion-resistant central body portion of the tread rubber and said rubberized breaker layer to the carcass at the tire crown while bonding said edge portions of the tread rubber layer to said flexible side wall rubber layers; and vulcanizing the green casing thus formed.

The invention in another aspect provides a pneumatic radial tire comprising a pair of bead wires, a carcass extending from one of the two bead wires to the other and consisting of at least two rubberized carcass plies each having parallel cords disposed at from 70° to 90° to the equatorial plane of the tire, a pair of side wall rubber layers secured to the outer surfaces of the opposing side walls of the carcass, said side wall rubber layers having a Shore A hardness of from 40° to 55°, a rubberized breaker secured to the outer surface of the crown portion of the carcass and consisting of cords disposed at from 10° to 30° to the equatorial plane of the tire, and a tread rubber layer secured to the outer surface of the breaker and comprising a central body portion of hard rubber having a Shore A hardness of from 55° to 75° and a pair of edge portions bonded to said central portion and made of the same rubber material as said side wall rubber layers, wherein said edge portions, and adjacent parts of said central portion, of said tread rubber layer are bonded to said side wall rubber layers and on each side of the tire, as viewed in a section on a radial plane containing the axis of rotation of the tire, the boundary line between a said edge portion of the tread rubber layer and the said central portion of the tread rubber layer intersects at an acute angle the boundary line between the respective said side wall rubber layer and the said central portion of the tread rubber layer.

Such radial tires, having a crown portion covered with one rubber material and side wall portions covered with a different rubber material, may be efficiently manufactured and have a high crack resistance and a high resistance to separation of the side wall rubber layers from the tread rubber layer.

The invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view through a radial tire manufactured by a conventional process;

Figure 2 is a sectional view through a radial tire manufactured by an improved conventional process;

Figure 3 is a partly sectional view through the tire shown in Figure 2 during a stage of its manufacture;

Figures 4A to 4C are partly sectional views illustrating the manner in which the tread portion of the tire shown in Figure 2 is formed;

Figure 5 is a partly sectional view, showing the first step of the present process for manufacturing a radial tire;

Figures 6A and 6B are partly sectional views, showing the second step of the present process for manufacturing a radial tire;

Figures 7 is a sectional view of a tread rubber layer to be used in the present process;

Figure 8 is a view of a finised radial tire manufactured by the present process, being half in section;

Figure 9 is a schematic view showing a part of a tire manufactured by a conventional process on the left-hand side of the Figure and a part of a tire manufactured by the present process on the right-hand side; and

Figure 10 is a schematic view similar to Figure 9 being an enlarged view of parts of the tread portions of the respective tires.

Like parts are designated by like numerals and symbols throughout the drawings.

In the radial tire shown in Figure 1, manufactured by a conventional process, a rubber layer covering the tire outer surface comprises a tread rubber layer 5 and a pair of side wall rubber layers 3, 3^1. In the manufacture of such a tire the side wall rubber layers 3, 3^1 are secured to a carcass 2 as a first step of the process, and the tread rubber layer 5 is secured to the carcass 2 as a second step.

Such a conventional process suffers from the disadvantage that the tread rubber layer 5 and the side rubber layers 3, 3^1 tend to easily separate along joints *j*, due to the different rubber materials used for the two kinds of layers. Thus, radial tires made by the conventional process are susceptible to serious separation faults. Furthermore, the side wall rubber layers 3, 3^1 thus formed tend to produce cracks. Accordingly, the durability of radial tires made by this conventional process has been rather poor.

In order to obviate such difficulties, it has previously been proposed to modify the direction of the joints *j* between the tread rubber layer 5 and the side wall rubber layers 3, 3^1, as shown in Figure 2. A complicated process is required to make the joints *j* shown in Figure 2. In the first step of the prior process, rubber-repellent sheets 4, e.g., polyethylene sheets, are inserted between the crown portion of a carcass 2 on a former 1 and side wall rubber layers 3, 3^1 to prevent the side rubber layers 3, 3^1 from being directly bonded to the carcass 2, as shown in Figure 3. Before carrying out the second step of the process, the radially outer edges of the side wall rubber layers 3, 3^1 are moved away from the carcass 2, as shown in Figure 4A. After removing the rubber-repellent sheets 4, a breaker layer 6 and a tread rubber layer 5 are secured to the carcass to complete the second step, as shown in Figure 4B. Then, the radially outer edges of the side wall rubber layers 3, 3^1 are bonded to opposite side surfaces of the tread rubber layer 5, for example by stitcher rolls SR, as shown in Figure 4C.

The process described with reference to Figures 3 and Figures 4A to 4C produce a radial tire having an improved performance, but it is too complicated to efficiently manufacture radial tires.

Figure 5 illustrates the first step of the present process for manufacturing radial tires and shows a carcass 2 including carcass plies assembled on a cylindrical former 1, together with bead wires, bead fillers and chafers; the carcass plies consist of cords disposed to lie at from 70° to 90° to the equatorial plane of the tire. A pair of sidewall rubber layers 3, 3^1, each consisting of a flexible rubber material with a Shore A hardness of from 40° to 55° (when vulcanized) are spread and bonded to the carcass 2 to form an intermediate tire assembly. In a second step of the process, the intermediate tire assembly is transformed into a toroidal shape, which approximates to the finished shape of the tire. A breaker layer 6, consisting of one or more rubberized cord sheets comprising cords disposed to lie at from 10° to 30° to the equatorial plane of the finished tire, is secured to the crown portion of the toroidal carcass 2, and a tread rubber layer 5 is then bonded to the breaker layer 6, as shown in Figure 6A. The assembly thus formed is then shaped into a green casing, e.g., by stitcher rolls SR, as shown in Figure 6B.

It is an important feature of the present process that the tread rubber layers 5 to be secured to the breaker 6 on the tire crown portion is pre-formed, e.g., pre-extruded by using two different rubber materials. More particularly, the tread rubber layer 5 to be used in the present process comprises three portions; namely, a central body portion A and a pair of side edge portions B, B^1, as shown in more detail in Figure 7. The central portion A is made of an abrasion-resistant rubber material with a Shore A hardness of from 55° to 75°, while each side edge portion B, B^1 is made of another rubber material which is flexible and has a Shore A hardness of from 40° to 55°. The rubber material for the side edge portions B, B^1 of the tread rubber layer 5 is the same as that of the sidewall layers 3, 3^1. Thus, the properties of the side edge portions B, B^1 of the tread rubber layer 5 are the same as those of the sidewall rubber layers 3, 3^1.

The green casing formed in the second step is vulcanized in a third step.

The joints thus made by the present process between the side portions B, B^1 of the tread rubber layer 5 and the sidewall rubber layers 3, 3^1 are much stronger than the corresponding joints *j* of tires made by conventional processes, because the joints formed in the present process are between similar rubber materials while points formed in conventional process are between dissimilar rubber materials. The bond between the central portion A and the adjacent side edge portions B, B^1 of the tread rubber layer 5 is very strong, as such a bond is formed by extrusion.

In addition, the elimination of the use of rubber-repellent sheets 4 in the present process results in a considerable simplification of the manufacturing process.

Therefore, the durability of the radial tire made by the present process is materially improved in a very simple fashion, compared with that of radial tires made by conventional processes.

The details of assembling the elements in the first step and the formation of the green casing in the second step are well known to those skilled in the art, and accordingly it is not necessary to describe such details. The vulcanization of the green casing in the third step is also carried out in a known manner.

In the radial tire shown in Figure 8 made by the present process the joints *j* between the two different rubber materials are wedge shaped, and hence the resistance to separation of the two materials is greatly improved compared with radial tires made by conventional processes.

To clarify the difference between radial tires made by the present process and the radial tires made by the conventional process, parts of the two tires are depicted side by side in Figures 9 and 10; namely, Figure 9 shows on the left-hand side a part of a tire manufactured by a conventional process, and shows on the right-hand side a part of a tire made by the present process, an Figure 10 is an enlarged view showing similar parts of the tread portions. The shape of the joints *j* between the two different rubber materials formed by the present process is clearly shown in Figures 9 and 10.

On each side of the tire, as viewed, in a section on a radial plane containing the axis of rotation of the tire, the boundary line between the edge portion B or B^1 or the tread rubber layer 5 and the central portion A of this layer intersects at an acute angle X the boundary line between the side wall rubber layer 3 or 3^1 and the central portion A of the tread rubber layer.

The invention will be further described with reference to the following examples.

EXAMPLE

Radial tires of 175 SR 14 type were made by the present process described above with reference to Figures 5 to 7. Reference radial tires of the same 175 SR 14 type were made according to the conventional process described above with reference to Figures 3, 4A, 4B and 4C. The same materials, with the exception of the rubber-repellent sheets 4 and the tread rubber layers 5, were used for both the present process and the conventional process, namely the carcass 2, the breakers 6, and the side wall rubber layers 3, 3^1 were the same in both processes. Each carcass 2 included two rubberized parallel cord plies, whose cords each consisted of two twisted 840 denier yarns. Each breaker comprised four rubberized cord plies, whose cords each consisted of three twisted 1650 denier yarns. The conventional process used rubber-repellent polyethylene sheets 4.

Referring to Figure 3, in the first step of the conventional process, an intermediary tire assembly was made on a cylindrical former 1 of 348 mm diameter and 337 mm width, by mounting a carcass 2, bead wires, bead filler, chafers, and two side wall rubber layers 3, 3^1 thereon in succession. Each of the wall side rubber layers 3, 3^1 was 95 mm wide, and a 75 mm wide polyethylene sheet was inserted between the carcass 2 and each side wall rubber layer 3, 3^1. More particularly, 70 mm of the entire width of each polyethylene sheet 4 was inserted between the associated side wall rubber layer and the carcass 2, but its remaining 5 mm wide edge portion was further extended toward the tire equator beyond the radially outer edge of the side wall rubber layer 3, 3^1. Thus, the 5 mm portion of the polyethylene sheet 4 has left uncovered by the side wall rubber layer.

In the second step of the conventional process, the intermediary tire assembly was removed from the former 1 for mounting on another former, so as to transform it into a toroidal shape by forcing the two beads toward each other. As a result, the outer radius of the carcass 2 along the tire equator increased to 385 m. The side wall rubber layers 3 and 3^1 were partially separated from the carcass 2 of the toroidal shape, together with the polyethylene sheets 4, as shown in Figure 4A. The breaker layer 6 of the aforesaid construction and a tread rubber layer 5 were secured to the crown portion of the carcass 2, in succession, as shown in Figure 4B. Thereafter, the side wall rubber layers 3 and 3^1 were returned toward the tire crown portion and bonded to the carcass 2 and the tread rubber layer 5, for further shaping into a green casing, as shown in Figure 4C.

In the first step of the present process an intermediate tire assembly was made in the similar manner to that of the first step of the conventional process by using the same former 1 and the same material, except that no polyethylene sheets 4 were used. In the second step of the present process, the intermediate tire assembly was transferred from the former 1 to the other former, so as to be transformed into a toroidal shape and formed into a green casing, in the same manner as described in the foregoing with respect to the corresponding second step of the conventional process, except that, in the present process the breaker layer 6 and the tread rubber layer 5 were directly mounted on the crown portion of the toroidal carcass 2 in succession, without separating any part of the side rubber layers 3 and 3^1, as shown in Figure 6A.

The tread rubber layer 5 used in the present process was vastly different from that used in the conventional process. The tread rubber layer 5 in the conventional process was solely made of an abrasion-resistant

rubber material, but the tread rubber layer 5 used in the present process was made of two different rubber materials, as described above with reference to Figure 7. The tread rubber layer 5 used in this Example for the present process had a top width TW of 140 mm (corresponding to the tread width of a finished radial tire), which was defined by the top surface of the central body portion A made of an abrasion-resistant rubber material with a Shore A hardness of 66° (when vulcanized). Triangular section side edge portions B and B^1 were secured to the opposite sides of the central portion A, each of which side edge portions had a bottom width of 10 mm and height of 10 mm. The side edge portions B and B^1 were made of a flexible rubber material with a Shore A hardness of 46° (when vulcanized). The tread rubber layer 5 consisting of the central portion A and the side edge portions B, B^1 was pre-extruded.

Both the green casing made by the conventional process and the green casing made by the present process were vulcanized at 165°C for 22 minutes in a metal mold.

Tests on the tires manufactured by the present process on the conventional process showed that a time saving of about 30% was obtained in the second step of the present process compared with the second step of the conventional process, due to the elimination of the three factors; namely, the removal of the polyethylene sheets 4, partial separation of the side wall rubber layers 3 and 3^1, and the return of the side wall rubber layers.

Durability tests were made on the tires thus made, and it was found that the resistance to the separation of the two different rubber material layers was improved by at least 5%, in the tires manufactured by the present process.

WHAT WE CLAIM IS:—

1. A method of manufacturing a pneumatic radial tire, comprising: forming a carcass including at least one rubberized carcass ply on a cylindrical former, securing a par of flexible side wall rubber layers to said carcass, said carcass ply consisting of cords disposed to lie at from 70° to 90° to the equatorial plane of the finished tire, said side wall rubber layers having a Short A hardness of from 40° to 55° (when vulcanized); forming a green casing by flexing the carcass thus formed into a toroidal shape, securing a rubberized breaker layer and a pre-formed tread rubber layer to the crown portion of the carcass by stitching, said breaker layer consisting of cords disposed to lie at from 10° to 30° to the equatorial plane of the finished tire, said tread rubber layer comprising a central body portion made of an abrasion-resistant hard rubber material with a Shore A hardness of from 55° to 75° (when vulcanized) and a pair of edge portions made up of the same rubber material as said side wall rubber layers and integrally pre-bonded to said central body portion, said stitching bonding said abrasion-resistant central body portion of the tread rubber and said rubberized breaker layer to the carcass at the tire crown while bonding said edge portions of the tread rubber layer to said flexible side wall rubber layers; and vulcanizing the green casing thus formed.

2. A method as claimed in Claim 1 wherein the said carcass comprises two rubberized cord plies, each cord having two twisted 840 denier yarns.

3. A method as claimed in Claim 1 or 2 wherein the said breaker comprises four rubberized cord plies, each cord having three twisted 1650 denier yarns.

4. A method as claimed in any of Claims 1 to 3 wherein the tread rubber layer has been pre-extruded using two different rubber materials so as to integrally form the said central body portion and the said edge portions in one operation.

5. A method according to Claim 1 substantially as herein described with reference to, and as shown in, the accompanying drawings.

6. A method according to Claim 1 substantially as herein described with reference to the foregoing example.

7. A tire when manufactured by the method claimed in any of Claims 1 to 6.

8. A pneumatic radial tire comprising a pair of bead wres, a carcass extending from one of the two bead wires to the other and consisting of at least two rubberized carcass plies each having parallel cords disposed at from 70° to 90° to the equatorial plane of the tire, a pair of side wall rubber layers secured to the outer surfaces of the opposing side walls of the carcass, said side wall rubber layers having a Shore A hardness of from 40° to 55°, a rubberized breaker secured to the outer surface of the crown portion of the carcass and consisting of cords disposed at from 10° to 30° to the equatorial plane of the tire, and a tread rubber layer secured to the outer surface of the breaker and comprising a central body portion of hard rubber having a Shore A hardness of from 55° to 75° and a pair of edge portions bonded to said central portion and made of the same rubber material as said side wall rubber layers, wherein said edge portions, and adjacent parts of said central portion, of said tread rubber layer are bonded to said side wall rubber layers and on each side of the tire, as viewed in a section on a radial plane containing the axis of rotation of the tire, the boundary line between a said edge portion of the tread rubber layer and the said central portion of the tread rubber layer intersects at

an acute angle the boundary line between the respective said side wall rubber layer and the said central portion of the tread rubber layer.

9. A pneumatic radial tire according to Claim 8 substantially as herein described with reference to, and as shown in, the accompanying drawings.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1974.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

Fig.1

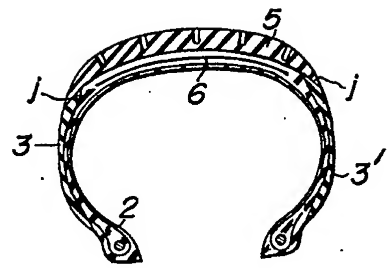

Fig.2

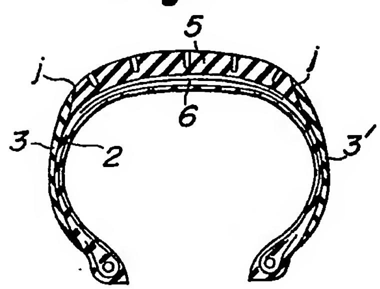

Fig.3

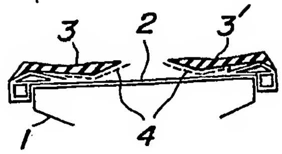

Fig.4A

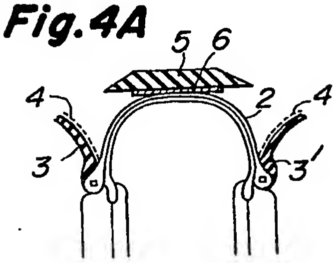

Fig.4B

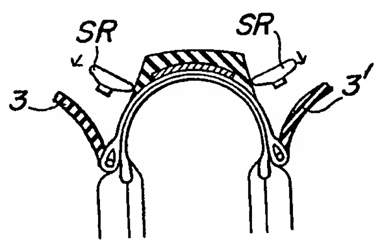

Fig.4C

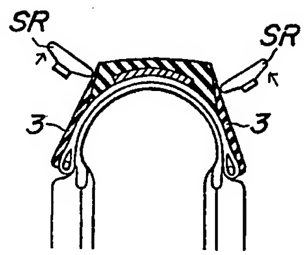

Fig.5

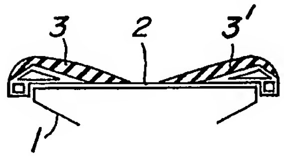

Fig.6A

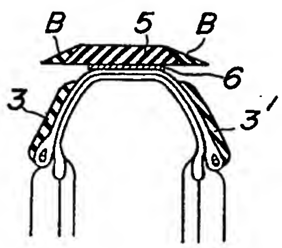

Fig.6B

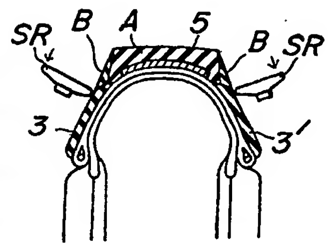

Fig.7

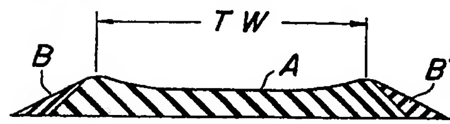

Fig.9

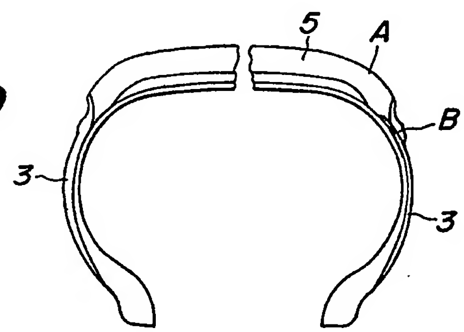

Fig.8

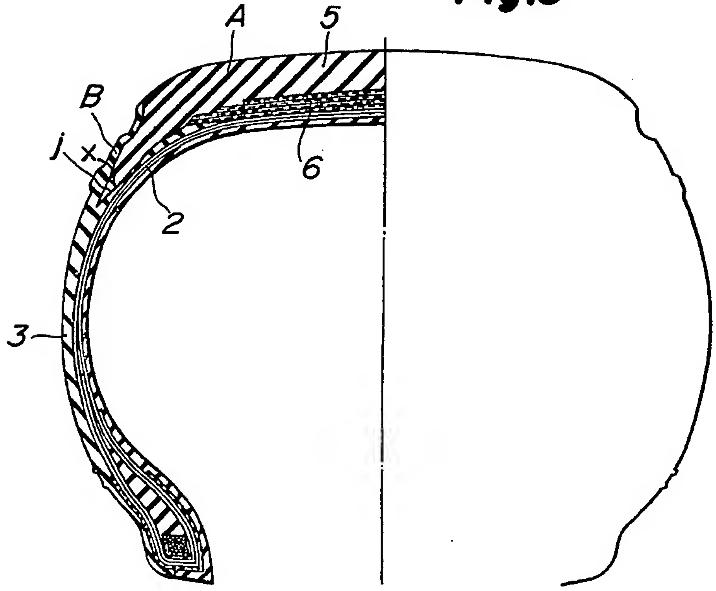

Fig.10